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Evaluation and Optimization of Building Greening Methods in Four Different Climates Using Building Information Modeling (BIM)

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Abstract

BIM, which stands for Building Information Modeling, is a methodology that allows architects to digitally simulate their design and manage all the information related to an architectural project. BIM systems include the fourth dimension (time dimension) and the fifth dimension (cost dimension). On the other hand, sustainable development is a complex concept that includes different aspects. In sustainability, the three economic, environmental, and social aspects are fully interacting with each other, and most researchers examine sustainability in these three main aspects (Triple Bottom Line) of environmental, social, and economic sustainability. Therefore, in this research, we have examined four objectives, which first evaluate the impact of building orientation on reducing energy consumption by using building information modeling (BIM) and determine the most optimal direction. Then we examine the effect of the placement of skylights and openings on reducing energy consumption by using building information modeling (BIM). Finally, we examine the effect of using green facades and building smartness on the energy consumption of the building. Finally, by comparing the results obtained from the Design-Builder software, the most optimal modes are determined.

Keywords: BIM, sustainable development, Energy Plus, green building, Design builder.

Introduction

Every building should be designed and built in such a way that its need for fossil fuel is minimized. The necessity of following this principle in the past eras is undeniable, without any doubt, considering the way of construction. Perhaps only because of the huge variety of new materials and technologies in the contemporary era, such a principle has been forgotten in buildings, and this time, by using different materials or with different combinations of them, the buildings and the environment are changed according to the needs of the users. Mentioning the biological complex theory is also not without grace (Iravani & Ahd, 2021-a; Ciardiello et al., 2020).

Which originates from providing shelter to be safe from the cold or creating a cool space for people to live, for this reason as well as the presence of other factors, people built their buildings next to each other because of many mutual benefits. The increase in the world's population and their need for the nature around them to meet their needs has had a destructive effect on nature. Among these effects, we can mention global warming, air and water pollution, damage to the ozone layer, threats to renewable and non-renewable resources, deforestation, soil degradation, increasing the amount of waste, and extinction of plants and animals (Khanian et al., 2019).

The growing awareness of environmental aspects and the demand for sustainable buildings around the world shows that the current situation as it exists in the construction industry cannot easily continue. It seems that with the help of the concept of sustainability in the way of construction and architecture, it is possible to achieve goals such as preserving nature, preventing its threatening effects, and at the same time responding to human needs (Iravani & Ahd, 2021-a). In this regard, it is possible to provide solutions for the existing problems with a scientific point of view, which, while responding to them, will also affect the architectural design and atmosphere.

Due to the increase in construction and the increase in the use of non-renewable energy, today one of the most important issues in the construction industry is the construction of buildings with minimal use of non-renewable energy, which is acceptable in developed countries (Ghadarjani et., 2013). The problem is obvious. Greening buildings helps this process by minimizing the use of non-renewable energy and increasing the use of renewable energy or natural energy such as the sun or wind. There are different definitions of green buildings, and the common members of all these definitions include life cycle, environmental sustainability, and issues related to health and its effects on society.

In general and in simpler terms, a green building can be considered as a building based on environmental principles, in which an attempt is made to reduce production pollution in the construction, operation, and demolition stages, such as noise pollution, water, dust, and emissions. Greenhouse gases as well as the use of renewable energy and minimizing the consumption of non-renewable energy. In the general form of research related to green buildings, it can be concluded that one of the main goals of these issues is to meet the needs of today's society without jeopardizing the ability to meet the needs of the future.

Green buildings should be designed in such a way that they can use the local climate and energy sources. At the same time, through the correct insulation of the structure, they can also reduce the consumption of fossil energy. Due to the location of Iran in different geographical latitudes, Iran has four different climates, and in this research, greening in these four climates will be investigated.

- Hot and dry climate (central plateau)
- Hot and humid climate (south coasts)
- Moderate and humid climate (southern shores of the Caspian Sea)
- Cold climate (western mountains)

Theoretical foundations and vocabulary of research

In this research, the BIM building information modeling method is used, so it is necessary to explain BIM first. Building Information Modeling is defined as a set of parametric information that is used to make design decisions, create quality building plans, predict building performance, estimate costs, schedule, maintain and operate methods, and manage contracts and procurement. Green construction refers to the entire life cycle of the building, which creates a kind of harmony in nature. In the field of green and sustainable buildings, BIM can be combined with analog energy constructions and analysis of light radiation flows and ecosystems of buildings can be done in this way (Li & Liu, 2020).

By using BIM, it will be possible to reduce waste and improve the quality of yacht construction through multi-dimensional digital design options. BIM provides visualization of digital building models through multidimensional digital design options. This is done by creating special collaboration platforms in simulation and analysis for designers, architects, facility engineers, builders, and even end users. BIM helps these people to make the most of 3D digital models in the design and construction of projects and operation management.

In this research, greening methods are first defined and then these methods are applied on a one-story building with residential pilot and type map using building information modeling, and the results of building energy consumption and resulting pollution in each method are announced and optimal methods are concluded.

Basic principles in the design of green buildings. While several definitions have been provided for green buildings, the National Building Institute defines the basic principles for it as follows:

Optimizing the potential of the site. The design or sustainable improvement of structures, in a successful project, requires the right choice of the location, orientation, and perspective of the building. These cases generally affect transportation methods and sustainable energy consumption that is compatible with the environment.

Optimizing energy consumption. Optimizing energy consumption in buildings is important to reduce dependence on fossil and non-renewable fuels. Protection of water resources: the correct use of water resources and, if possible, purifying and reusing used water.

Optimum use of building space and consumable materials. Due to the increase in population, the demand for using natural resources is increasing day by day. The optimum use of resources in a green building is of particular importance.

Improving the quality of the indoor environment of the building. The air quality in the indoor environment of a building has a significant impact on the health of its residents. To achieve this goal, it is through air conditioning and humidity control systems, sound and thermal insulation of the building, and limiting the use of environmentally polluting materials.

Optimizing the use and maintenance of green buildings. Using materials and materials that make the maintenance of the building easy require less water, energy, toxic substances, and detergents for maintenance, and are economically affordable.

Application of BIM. The first application of BIM that can be referred to as a concept is updating information and different stages of the project life cycle to reflect the role and cooperation of stakeholders, which facilitates communication and sharing of studies between stakeholders and agents involved in the project. BIM is used in all phases of the project and can be used to better understand the needs of the project by the relevant stakeholders, thereby reducing errors, changes, and rework, which leads to a more efficient transformation, including reducing time and cost (Gheitaraniet al., 2020; Gheitarany et al., 2013). One of the main functions of BIM is to analyze constructability through simulation increase productivity and reduce interference in construction projects. The main pillar of BIM is the cooperation of the factors involved in the project at different stages of its life cycle. It has created a new interaction in construction, which has created a very high level of coordination between the employer, designer, builder, and operator.

Using BIM for Construction Management

Visualization. Interpretations can be added to a 3D model.

Reviewing standards. Organizations such as the fire department and departments can use it to review construction projects.

Analysis. A building information model can document and graphically show the damage to seats and so on.

Facilities management: This department can use BIM for renovation, space planning, and maintenance operations.

Cost estimation: One of the main features of BIM is cost estimation, which can automatically extract the amount of materials and apply and estimate any changes at different times in the built model.

Construction sequence: The building information model can be effectively used to arrange the materials or the construction and delivery stages according to the schedule for the completion of the building components (Hernánde et al., 2021).

Interference and collision detection. The BIM model gives us a three-dimensional image with a scale of all the components of the building, according to which it can be checked that the pipes of the air ducts or other components do not collide with the structure or the main walls, and in general, the various components of the building do not interfere with each other and

Definition of sustainable building

A sustainable building can be defined as follows. "The building that has the least incompatibility with the natural environment around it and in a wider area with the region and the world". In general, the general goals pursued by the construction of sustainable buildings are:

- Proper use of resources and energy
- Preventing air pollution
- Compliance with the environment
- LEED energy management and climate design certificate

Methodology

Programs and open codes - special program. Open programs are programs that can be used for different types of buildings with different structures and different regions with little changes in the input data.

Most of the known programs are of open source type (such as BLAST (TRANSYS-DOE 2- In these programs, the building location, building components, climatic data, and heating and ventilation systems, etc. must be given as input to the program so that energy calculations can be done. Of course, if the costs of the life cycle of the building are also requested, economic data and the period of use of the building must also be given to the program.

Many computer programs have been obtained for the analysis of building heat and energy consumption, and these programs are increasing day by day. The use of these programs has been started since 1980 in Denmark and several other countries. The result of a complex relationship between the design and composition of the building, the heat loads inside the rooms, the cooling and heating system, and the air conditioning, as well as the climatic conditions of the environment outside the building. Therefore, it is necessary to establish a thermal balance between the inside and outside of the room.

Energy calculations. The purpose of energy calculations is to estimate the annual energy consumption of the building. Several models and methods have been provided to estimate the annual or monthly energy consumption of a building, which can be divided into 3 categories:

Stable methods (in terms of heat transfer)

Semi-permanent methods/ unstable methods. Where steady state conditions are assumed, there are no changes in the amount of heat of building structures with time (for example, during the day or month).

These methods cannot be used for a situation where the internal or external conditions change drastically with time. Some of the semi-permanent methods are such that, for example, for the energy obtained from the sun or the heat obtained inside the room (people-electrical devices, etc.), they assume monthly or yearly values on average.

That is, these types of programs do not pay attention to the details of how energy consumption changes over time and are only able to pay attention to these energies on a monthly or yearly basis. In unstable methods, energy consumption changes are calculated instantaneously. Therefore, in this case, establishing thermal balance in the building will be very complicated. In these methods, more details of geometry, and climatic conditions should be compared to sustainable methods. Figure 1 shows the simulation process. This process includes 4 main parts.

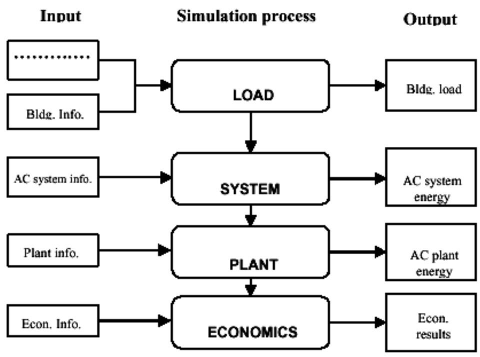

Figure 1. Energy simulation process in the building

Each part has its input data and also the results of each part are used in the next part.

Now each of these parts is explained:

Load. The input data for this part is the design and climatic data of the building, which are used to calculate the building loads.

Electrical systems. In this section, using the input data, the amount of electrical energy consumption of the desired building is calculated.

Electrical systems and equipment fuel. In this part, the amount of electrical energy and fuel consumption of the air conditioning equipment and devices is calculated.

Economy. In this section, using economic data, the building is also examined from an economic point of view.

Important and main elements of simulation. The main elements of energy simulation in the building, which include 4 main models to determine the effective combinations in energy consumption, are:

1- Building model

2- Air conditioning system model (HVAC)

3- Model of air conditioning equipment and devices

Building control model

The building design shows the design options and the right side shows the simulation options. According to this figure, it can be seen that the design part includes two design parts in terms of architecture and engineering (Gheitarany et al., 2013; Kahvand et al., 2015). First, the items related to architecture such as the form, shape, materials, and structures of the building are designed by the architect-engineer, then from the data obtained from this part, the required items for the simulator program are extracted and given to the program, and this program also shows its results. By using the algorithms and assumptions that the program, presents (Fathi et al., 2020; Gheitarany et al., 2013).

These program output data are used in the engineering design part to determine the type of system and equipment needed for the building. Computer programs for building energy simulation are constantly evolving and changing, so it is important to have sufficient knowledge about the features, applications, and limitations of simulation tools.

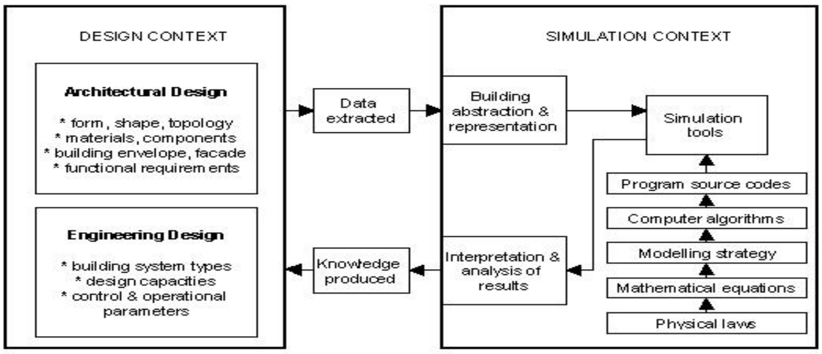

Figure 2. The relationship between building design and simulation

Building zoning. The building to be modeled should be divided into several areas. These areas may be the rooms of the building or parts of the rooms that have similar thermal conditions. Therefore, the building model may be divided into more areas than the number of rooms in the building (Hao et al., 2023). Of course, as the number of these areas increases, the accuracy of design and simulation will also increase (Iravani & Dehghan, 2022). When we have large rooms in a building, these rooms can be divided into several areas depending on the thermal conditions of the room (Ghadarjani & Gheitarani, 2013). Often there will be similar areas and parts in a building. In this case, the conditions of these parts can be obtained only by calculating one of the parts.

The main conditions that cause the separation of the regions can be stated as follows:

A) The amount of solar heat gain in the area

b) The amount of acquired heat inside the room and sources of energy production inside

c) Area ventilation conditions (ventilation system structure, air change ratio inside, number of hours the system is active)

d) How to control the heating and cooling systems in the area

It should be noted that reducing the number of regions leads us to calculations and less time in energy simulation. Accordingly, small rooms inside the building can be considered as one area if they have almost the same thermal conditions.

Weather data. Simulation programs usually perform calculations on an hourly basis to determine the internal conditions of the building. This work requires the use of climatic information (radiation and temperature). In addition to the climatic data, it is necessary to specify the geometry and also the way the sun's rays hit for all hours of the year. These climatic data should not be averaged over the year or only for a part of the year. Rather, they should be known daily and in all 8760 hours of the year.

Material database. All thermodynamic properties required for building energy simulation must be specified. Of course, most of the computer programs have their library in which the thermodynamic properties of different materials are presented. If the material desired by the user is not available in this library, the user himself can add this material to the program library.

ENERGY PLUS program. It is a new program for building energy simulation based on a combination of BLAST and DOE2 programs. Of course, this program performs the analysis in times shorter than one hour and is based on a thermal balance of the entire simulation area. It should be noted that the DesignBuilder software uses the ENERGY PLUS solver and its results are the same as the results of this software (Maleki et al., 2023)**.**

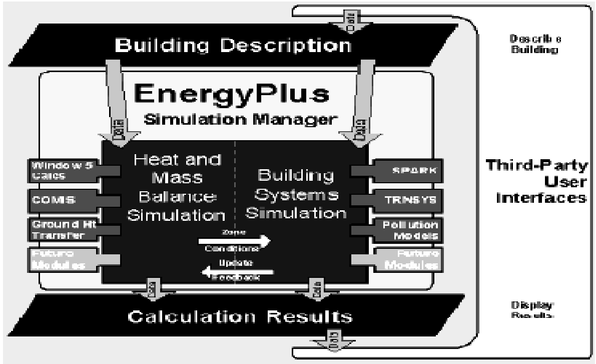

Figure 3. The main structure of the program.

It can be seen in this figure that this program uses the following programs for simulation analysis:

- WINDOWS5 – COMIS – GROUND HEAT TRANSFER
- SPARK – TRNSYS – POLLUTION MODELS

These programs are divided into two parts, the thermal simulator and the simulator of the systems used in the building. The ENERGY PLUS program performs detailed and accurate modeling and also has many standard tests to compare systems. The weakness of this program is that it does not use an easy graphic system for input data and it needs programs that can design the building or examine the results. This program is written in FORTRAN and calculates the energy required for cooling and heating the building from different energy sources. This work is done by simulating the building and related energies in different environmental and work conditions. Energy Plus is an integrated simulator that consists of three main parts: the ventilated environment (building), the system, and the facilities.

In this software, all three parts are analyzed at the same time. In Energy Plus, the system is considered integrated and generally, the solution methods rely on successive iterations. Taylor used the time marching method for fast simulation in a certain time interval, in which the air-conditioned space is linked to time intervals (Iravani & Ahd, 2021-b). The error obtained from this method has a close relationship with the time intervals. If they are smaller, although the calculation time increases, the error decreases. From solving the energy balance equation, the resulting equations are obtained, which are the basis of Energy plus calculations.

The term on the left side is the equation of the energy stored in the indoor air, and the first term on the right side is the sum of the internal displacement loads, the second term is the displacement heat transfer from the surfaces of the investigated area, the third term is the heat transfer due to the mixing of the incoming air, and the fourth term is the heat transfer due to the temperature change. The output air shows the internal temperature.

Qsys represents the thermal and cooling load to be supplied by the equipment. In equilibrium conditions, it will be = 0. In this thermal software, thermal simulation is accompanied by trial and error, and this is how the amount of energy required to establish equilibrium with the environment is estimated from the above equation. And then according to the estimated amount of energy, the system is simulated. And if necessary, the equipment related to the facilities will also be simulated. Then it is calculated according to the actual power of the environment temperature.

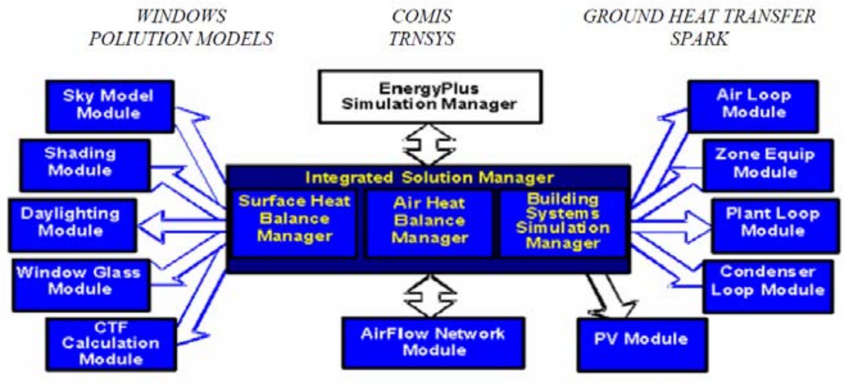

Figure 4. Estimated amount of energy in Design Builder

Software specifications. This software analyzes the heat transfer in an unstable way and throughout the year for shorter periods (every 10 minutes). In this software, different models are used to consider the effects of radiation and convection on internal surfaces. In this software, by presenting hourly climate data to the software, the analysis can be performed for the whole year or a specific day. In this software, the whole building should be designed in 3D (Iravani & Ahd, 2021-b; Hernández et al., 2021). This software can define heat sources inside the building (people and electrical devices, etc.). In this software, external surfaces can be defined as desired and the shadow effects of these surfaces can be obtained on the building.

Results and Discussion

Geometric characteristics of the building. In this research, a 6-story building has been modeled, and this building has an area of 120 square meters (more precisely, 12 meters long and 10 meters wide). The materials used in this building are of common types and their specifications are as follows.

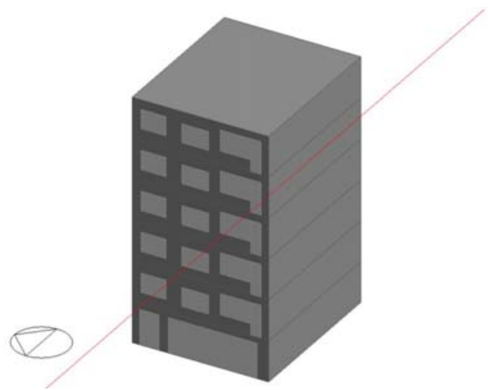

Figure 5. Modeled building view in Design Builder

Specifications of building walls

The building has internal and external walls, a roof, and a floor with the following specifications:

External walls

- External walls have three layers, from outside to inside:
- The first layer:
- Consists of a 10cm thick brick facade and the physical characteristics of the brick are as follows:
- Conductivity: 0.84 (wat/ (m.k)) Specific heat: 800 (j/ (kg. k)) Density: 1700 (kg/m^3)
- Second layer: 10cm thick cement block and its physical characteristics are as follows:
- Conductivity: 0.19 (wat/ (m.k)) Specific heat: 1000 (j/ (kg. k)) Density: 600 (kg/m^3)
- The third layer: Was gypsum plastering and its physical characteristics are as follows:
- Conductivity: 0.4 (wat/ (m.k)) Specific heat: 1000 (j/ (kg. k)) Density: 1000 (kg/m^3)
- The overall U-value of the wall is equal to (wat⁄(m^2 k) 0.518).

Roof specifications

The roof has three layers, from outside to inside:

The first layer: the asphalt layer is 1 cm thick and its physical characteristics are as follows:

Conductivity: 0.7 (wat/(m.k)) Specific heat: 1000 (j/(kg.k)) Density: 2100 (kg/m^3)

The second layer: is 14 cm thick glass wool insulation and its physical characteristics are as follows:

Conductivity: 0.04 (wat/(m.k)) Specific heat: 840 (j/(kg.k)) Density: 12 (kg/m^3)

The third layer: the air gap is 20 cm thick and its specifications are as follows:

Thermal resistance: 0.18 (m^2 k)/watt

The fourth layer: the plasterboard layer is 1.3 cm thick and its physical characteristics are as follows:

Conductivity: 0.25 (wat/(m.k)) Specific heat: 896 (j/(kg.k)) Density: 2800 (kg/m^3)

In general, the U-value for the roof is 0.25 (wat⁄(m^2 k)).

Floor specifications:

The floor has four layers, from outside to inside:

- The first layer: the outer layer of formaldehyde is 13 cm thick and its physical characteristics are as follows:
- Conductivity: 0.04 (wat/(m.k)) Specific heat: 1400 (j/(kg.k)) Density: 10 (kg/m^3)
- Second layer: 10cm thick concrete mold and its physical characteristics are as follows:
- Conductivity: 1.1 (wat/(m.k)) Specific heat: 1000 (j/(kg.k)) Density: 2000 (kg/m^3)
- The third layer: floor construction (sand) is 7cm thick and its physical characteristics are as follows:
- Conductivity: 0.41 (wat/(m.k)) Specific heat: 840 (j/(kg.k)) Density: 1200 (kg/m^3)
- The fourth layer: the flooring is 3 cm thick and its physical characteristics are as follows:
- Conductivity: 0.14 (wat/(m.k)) Specific heat: 1200 (j/(kg.k)) Density: 650 (kg/m^3)

In general, the U-value for the entire floor is equal to 0.25 wat/ (m^2 k).

The effect of a green roof. In this part, we will examine the effect of green roofs on reducing the energy consumption of the building, so that once we use the green facade and another time the green roof in the building, and the effect of each on the energy consumption of the building, as well as reducing the amount of carbon dioxide production of the building (Zaker Haghighi et al., 2014).

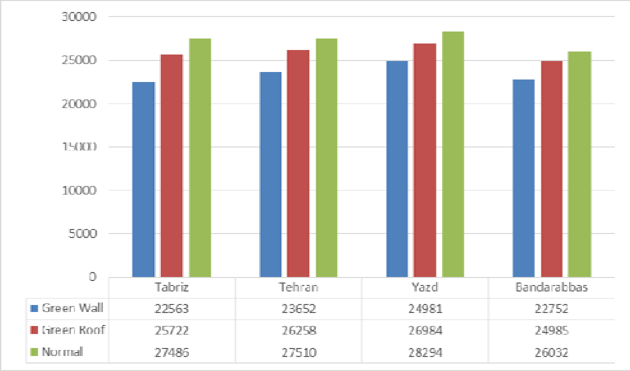

Figure 6. The diagram of the energy consumption of the building in the green facade

In the above graph, the amount of building energy consumption in three states of simple building, green facade, and green roof is shown in four different climates. In general, in all climates, the energy consumption of the building in a green facade is very different compared to the normal state. In the hot and humid climate (Bandar Abbas), the difference in answers is more than in other climates, and in general, the difference in answers is about 25% in the normal state and when using the green wall. In the graph below, we also examine the effect of green facades in reducing carbon dioxide production.

Figure 7. Diagram of the results of heating and cooling energy consumption

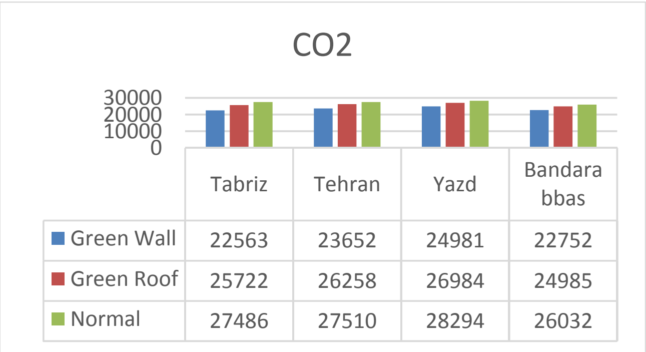

Figure 8. The carbon dioxide production diagram of the building in green view

According to the above graph, it can be seen that the amount of carbon dioxide production in the building has decreased significantly with the installation of a green facade and green roof so that the amount of carbon dioxide production in the building has decreased with the production of oxygen by plants on the facade and roof of the building. It is necessary to mention that the production of carbon dioxide in the building is due to heating cooling or cooking.

Career software calculations. To ensure more certainty, we calculate the thermal load and cooling load of the building using Carrier software. We load all the conditions mentioned in the previous parts of the research into the carrier software and then check the amount of thermal and cooling load for the city and climate of Tabriz. The results show that the thermal load obtained is equal to 184590 watts (Mofidi & Akbari, 2020). The manual calculation of the cooling load is an estimate and cannot be a very accurate criterion for comparison. For this purpose, we use Carrier software to calculate and validate the cooling load of the building with the above conditions. The figure below shows the results extracted from Carrier software for thermal and cooling load. According to the results below, the value obtained for the cooling load of the building in Tehran climate is equal to 68.45 kW.

Table 1. The results extracted from Carrier software for building for Tehran climate

TABLE 1.1.A. COMPONENT LOADS FOR SPACE " BLD1-F001-Z01 " IN ZONE " BLD1-F001-Z01 "						
	DESIGN COOLING			DESIGN HEATING		
	COOLING DATA AT Aug 1600 COOLING OA DB / WEB 38.4 °C / 23.8 °C OCCUPIED T-STAT 23.9 °C			HEATING DATA AT DES HTG HEATING OA DB / WB -6.7 °C / -8.8 °C OCCUPIED T-STAT 21.1 °C		
		Sensible	Latent		Sensible	Latent
SPACE LOADS	Details	(W)	(W)	Details	(W)	(W)
Window & Skylight Solar Loads	195 m²	20910	-	195 m²	-	-
Wall Transmission	452 m²	1560	-	452 m²	43768	-
Roof Transmission	0 m²	0	-	0 m²	0	-
Window Transmission	195 m²	2910	-	195 m²	36925	-
Skylight Transmission	0 m²	0	-	0 m²	0	-
Door Loads	0 m²	0	-	0 m²	0	-
Floor Transmission	1768 m²	0	-	1768 m²	55368	-
Partitions	0 m²	0	-	0 m²	0	-
Ceiling	0 m²	0	-	0 m²	0	-
Overhead Lighting	28543 W	11296	-	0	48529	-
Task Lighting	0 W	0	-	0	0	-
Electric Equipment	14272 W	3734	-	0	0	-
People	69	5270	0	0	0	0
Infiltration	-	0	0	-	0	0
Miscellaneous	-	0	0	-	0	0
Safety Factor	0% / 0%	0	0	0%	0	0
>> Total Zone Loads	-	45680		-	184590	0

Energy plus solver calculations

In this section, we display the graphs and results extracted from the energy plus solver for Tehran city.

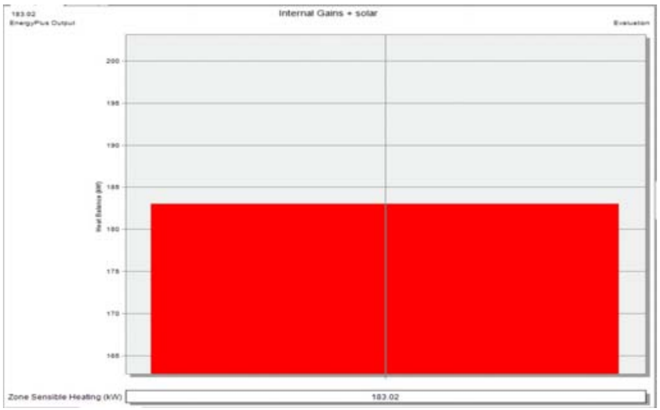

Figure 9. The amount of heat load of a simple building using Energy Plus solver for Tehran city

Figure 10. The amount of thermal load of a simple building using Energy Plus software for Tehran city

By comparing these values, it is clear that in the thermal load calculations for Tehran city, the results obtained from the software are about 5.2% wrong with the results of manual calculations and about 5.1% wrong with the calculations of Carrier software. Also, for the climate of Tehran (Zaker Haghighi et al., 2015), in the results of refrigeration load, the calculations performed in the Energy Plus and Carrier solver software showed that the results of Carrier's calculations are about 5.3% higher. In general, it can be concluded that the calculations made with the Energy Plus solver software have acceptable accuracy, and according to the capabilities and accuracy of the calculations made in this software, we can investigate the parameters considered in this research.

Conclusion

In general, the use of building greening methods has a significant effect on reducing building energy consumption, and this effect is different in different climates so each of the parameters examined in this research has been analyzed in four different climates. The process of conducting the research is as follows: first, we model a building in the software, then we analyze the effect of the orientation of the building so that we obtain the amount of energy consumption of the entire building in the four main directions and choose the most optimal direction (Mariano-Hernández et al., 2021). In the next step, we will examine the effect of the direction of the openings in the building, therefore, we will place the openings of the building in four main directions and get the amount of energy consumption of the entire building each time.

Now, after this step, we will examine the effect of green roofs and green walls in different climates and we will examine the effect of each on the amount of energy consumption reduction of the building. Finally, in the last stage, we examine the impact of the smartening of different parts of the building analyze each one, and obtain the impact of each part. The summary of the results obtained from the analysis of four different climates is as follows. The amount of energy consumption of the building in different directions has been investigated in four different cities. When the building is in the east and west directions, it has the highest energy consumption, and in the north and south directions, the energy consumption reaches its lowest state.

Among these, the south direction is the most optimal state, so it can be concluded that when the building is located in the south direction in different cities, energy consumption is the most optimal state. On the other hand, the most optimal answers in terms of energy consumption are related to the city of Tehran and the lowest amount of energy consumption is in the south direction (76652). In all climates, when openings are placed in the east and west directions, the energy consumption of the building increases dramatically. But when the openings are placed in the north and south directions, this value reaches its lowest value and the north direction is the most optimal state.

From this, it can be concluded that when the openings are located in the north direction of the building, the energy consumption of the building is the most optimal possible, and in the climate of Bandar Abbas, the energy consumption is generally higher than in other climates, and the reason for this is the hot weather. This climate is humid, which causes the cooling system to work more in this climate, and the lowest amount of energy consumption is related to the city of Tehran.

This climate is milder than other climates and requires less energy for cooling or heating. It should be noted that in Tabriz's climate, the difference in answers in different geographical directions is the lowest compared to other climates. In general, in all climates, the energy consumption of the building in the green facade is very different compared to the normal state. In the hot and humid climate (Bandar Abbas), the difference in answers is more than in other climates, and in general, the difference in answers is about 25% in the normal state and when using the green wall. The amount of carbon dioxide production in the building has been significantly reduced by installing a green facade and green roof.

So with the production of oxygen by plants on the facade and roof of the building, the amount of carbon dioxide production in the building is reduced. It should be noted that the production of carbon dioxide in the building is due to heating cooling or cooking. By making the building smarter, the amount of energy consumption during a year is significantly reduced, so in the meantime, by making the air conditioning system smarter, the reduction in energy consumption is more than in other cases and hot and humid and cold and dry climates. This amount is more than in other climates. And it reduces energy consumption in the building by about 30%.

Smartening windows and lighting also play a significant role in reducing building energy consumption. Especially in the hot and dry climate of Yazd, where the intensity of sunlight is higher in this region than in other regions. After examining the results obtained in this research, the following suggestions can be made for further research in this area:

- Investigating the effect of two-story facade buildings in different climates on the amount of energy consumption and building load
- The effect of using new energy and BIPV in high-rise buildings on the amount of electricity consumption and building lighting control during the day
- Investigating the effect of using phase change materials on the reduction of energy consumption in the building
- Investigating the use of geothermal resources to reduce building energy consumption and its economic analysis.

References

Ciardiello, A., Rosso, F., Dell'Olmo, J., Ciancio, V., Ferrero, M., & Salata, F. (2020). Multi-objective approach to the optimization of shape and envelope in building energy design. Applied energy, 280, 115984.

Fathi, S., Srinivasan, R., Fenner, A., & Fathi, S. (2020). Machine learning applications in urban building energy performance forecasting: A systematic review. Renewable and Sustainable Energy Reviews, 133, 110287.

GHADARJANI, R., & GHEITARANI, N. (2013). Methods for enhancing public participation in the rehabilitation and renovation of deteriorated housing (case study: Joulan neighborhood in the Hamedan City).

Ghadarjani, R., Gheitarani, N., & Khanian, M. (2013). Examination of city governorship pattern and citizen participation as a new approach to city management in region 5 of Isfahan municipality using T-test in SPSS. European Online Journal of Natural and Social Sciences, 2(4), pp-601.

Gheitarani, N., El-Sayed, S., Cloutier, S., Budruk, M., Gibbons, L., & Khanian, M. (2020). Investigating the mechanism of place and community impact on quality of life of rural-urban migrants. International Journal of Community Well-Being, 3, 21-38.

Gheitarany, N., Mosalsal, A., Rahmani, A., Khanian, M., & Mokhtari, M. (2013). The role of contemporary urban designs in the conflict between vehicle users and pedestrians in Iran cities (case study: Hamedan City). World Applied Sciences Journal, 21(10), 1546-1551.

Hao, X., Li, Y., Ren, S., Wu, H., & Hao, Y. (2023). The role of digitalization on green economic growth: Does industrial structure optimization and green innovation matter?. Journal of environmental management, 325, 116504.

Iravani, S. N. N., & Ahd, P. D. R. S. (2021-a). Examining Strain and Bending Deformation Parameters From Nonlinear Static Analysis of Concrete, Reinforced Concrete, and Fiber-Reinforced (FRP) Concrete Samples. Turkish Journal of Computer and Mathematics Education (TURCOMAT), 12(1), 7719-7728.

Iravani, S. N. N., & Ahd, P. D. R. S. (2021-b). Investigation of Retrofitting Reinforced Concrete Structures in Near-Fault Regions. Turkish Journal of Computer and Mathematics Education (TURCOMAT), 12(13), 7729-7738.

Iravani, S. N., & Dehghan, S. (2022). An Investigation to the Seismic Performance of Base Isolator-Equipped Moment Frame Steel Structures.

Kahvand, M., Gheitarani, N., Khanian, M. O. J. T. A. B. A., & Ghadarjani, R. A. Z. I. E. H. (2015). Urban solid waste landfill selection by SDSS. Case study: Hamadan. Environment Protection Engineering, 41(2), 47-56.

Khanian, M., Serpoush, B., & Gheitarani, N. (2019). Balance between place attachment and migration based on subjective adaptive capacity in response to climate change: The case of Famenin County in Western Iran. Climate and Development, 11(1), 69-82.

Li, J., & Liu, N. (2020). The perception, optimization strategies and prospects of outdoor thermal comfort in China: A review. Building and Environment, 170, 106614.

Maleki, M., Gheitaran, N., El-Sayed, S., Cloutier, S., & Giraud, E. G. (2023). The Development and Application of a Localized Metric for Estimating Daylighting Potential in Floor Plate. International Journal of Ambient Energy, (just-accepted), 1-28.

Mariano-Hernández, D., Hernández-Callejo, L., Zorita-Lamadrid, A., Duque-Pérez, O., & García, F. S. (2021). A review of strategies for building energy management system: Model predictive control, demand side management, optimization, and fault detect & diagnosis. Journal of Building Engineering, 33, 101692.

Mofidi, F., & Akbari, H. (2020). Intelligent buildings: An overview. Energy and Buildings, 223, 110192.

Zaker Haghighi, K., Gheitarani, N., Khanian, M., & Taghadosi, R. (2014). Examination of effects of urban street configuration on the amount of commercial buildings establishment (according to natural movement theory), Case study: Hamedan. European Online Journal of Natural and Social Sciences, 3(1), pp-20.

Zakerhaghighi, K., Khanian, M., & Gheitarani, N. (2015). Subjective quality of life; assessment of residents of informal settlements in Iran (a case study of Hesar Imam Khomeini, Hamedan). Applied research in quality of life, 10, 419-434.